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THE ESTABLISHMENT, PURPOSE, SCOPE, AND METHODS

OF THE STATE GEOLOGICAL SURVEY

BY GEO. H. ASHLEY

EXTRACT (A) FROM BULLETIN NO. 1, GEOLOGICAL WORK
IN TENNESSEE

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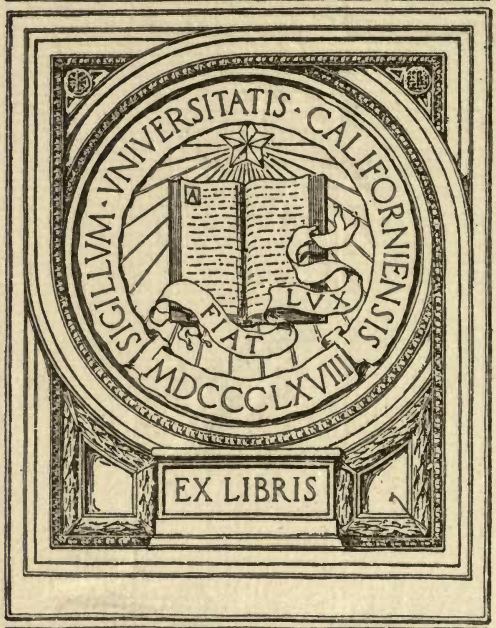

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STATE OF TENNESSEE—STATE GEOLOGICAL SURVEY

GEO. H. ASHLEY, State Geologist

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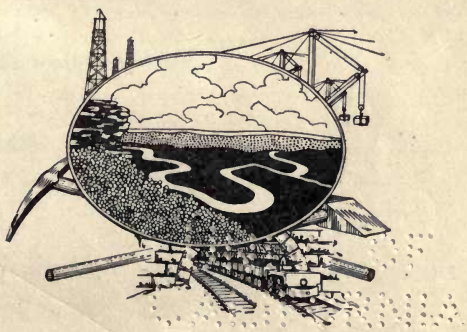

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THE ESTABLISHMENT, PURPOSE, SCOPE, AND METHODS OF THE STATE GEOLOGICAL SURVEY.

By Geo. H. Ashley.

THE ESTABLISHMENT OF THE SURVEY.

The natural resources of any State or nation form the basis of its material advancement, and their development and use measure its wealth and progress. Tennessee is rich in mineral and other resources. Extending from the oldest rocks in the crest of the Appalachians to the newest rocks forming the bottoms of the Mississippi River, there is embraced within its borders a variety and richness of soils, of climate, of rock strata, of zones of ores and other minerals, hardly excelled by any other State in the Union. This is reflected in the fact that to-day she leads every other Southern State, except Alabama, in mineral production; that her mineral production in 1908 was larger than that of North Carolina, South Carolina, Georgia, Mississippi, and Arkansas, all put together; more than twice as large as that of Florida, and nearly twice as large as that of Louisiana, but, on the other hand, only a little more than half as large as that of Alabama.

And yet, with a few exceptions, she is making relatively little use of many of her resources, as compared with some other States no more favored, except by markets, and to a large degree Tennessee is one of the markets of those other States, rather than supplying her own needs. Thus, with probably as large deposits of clay as Ohio, she produces to-day only about one-twentieth as much value in clay products, and goes to Ohio and other States to supply more or less of her own needs. With probably as large deposits of suitable material for the manufacture of cement as Indiana, she produces only one-eighteenth as much, and makes a market for

more or less of Indiana's supply. With many times as much iron ore as Pennsylvania, she produces only one-twenty-eighth as much pig iron. And similar examples might be multiplied. But it is not alone in the getting out of the materials that an advance is possible, but as much or more in their use. Every pound of raw material shipped out of the State is simply supplying some other State with wealth-making opportunities. Michigan supplies raw iron ore worth, in 1908, $2.85 a ton, and Pennsylvania works it up into pig iron worth about $15 per ton, or into steel rails or other materials worth still more. To how large an extent is Pennsylvania's wealth based on the natural resources of other States? To how large an extent is Tennessee to-day supplying other States with their wealth?

In the industrial awakening which for the last ten years has been going on in the South, Tennessee has been a leading figure. The whole country is coming to a realization that to-day the South stands for opportunity much as did the far West thirty to sixty years ago. This is strongly reflected in the increase of population of the Southern cities; in the multiplication of industrial plants of all kinds; in the reclamation of swamp lands and abandoned farms; in renewed interest in education, art, and literature; and in a thousand minor ways. To-day capitalists looking for investments and young men looking for opportunities to worthily win their way have their faces turned toward the South, and the young men of the South no longer feel it to be necessary to go North or West to find the larger opportunity they desire.

Under these circumstances there is a growing demand for information. Men will go where they know the things they desire exist. The clay man seeking new investments will hardly come to Tennessee when he reads in Reis' "Clays—Occurrences, Properties, and Uses:" "Probably less is known regarding the clays of Tennessee than of any other Eastern State." (Page 420.) He will go to some place where he has learned authoritatively that the clays he desires exist, and under the conditions of transportation, etc., he needs. Therefore, if Tennessee is to maintain the preëminence she has held, it will be necessary, not alone that she realize more fully the extent of her own resources and the possibilities of their use, but that she publish these facts to the world. Who can tell how much of her present position in mineral production Alabama owes to the labors of the efficient State Geological Survey she has so long maintained?

It was a realization of these facts that led the State Legislature

of Tennessee, in 1909, to provide for the establishment of a State Geological Survey.

THE BILL.

The bill establishing the Survey reads as follows:

CHAPTER 569.

SENATE BILL No. 300.

(By Messrs. Greer, Huffaker, and Neal.)

A BILL to be entitled An Act to establish and create the bureau to be known as the State Geological Survey; defining its objects, powers, and duties; providing for the appointment of a State Geologist, and defining his powers and duties; permitting coöperation with Federal and State bureaus in furthering the objects of this Act; providing for the publication of the results of the survey; providing for the collection of exhibits of the natural resources of the State, and for the final disposition of the equipment and property of the survey; authorizing entrance upon private lands in the prosecution of the work of the survey; and making the appropriations for the enforcement of this Act.

SECTION 1. *Be it enacted by the General Assembly of the State of Tennessee,* That there be, and is hereby, created and established a bureau to be known as the "State Geological Survey," which shall be under the direction of a Commission to be known as the "State Geological Commission," composed of the Governor (who shall be ex-officio Chairman of said Commission), the State Commissioner of Agriculture, the State Mine Inspector, the President of the University of Tennessee, the Chancellor of Vanderbilt University, and the Vice Chancellor of the University of the South.

SEC. 2. *Be it further enacted,* That the said Commission shall have general charge of the State Geological Survey and shall appoint as Director a Geologist of established reputation, who shall be known as the "State Geologist," and upon his recommendation such associate geologists, assistants, and employees as may be necessary to carry out successfully and speedily the work of the survey.

The Director, associates, assistants, and employees appointed under the provisions of this Act shall receive such compensation as shall be determined by the Commission. The said Commissioners shall serve without compensation, but shall be reimbursed for actual expenses incurred in the performance of their official duties.

SEC. 3. *Be it further enacted,* That the said Commissioners shall meet for organization within thirty days after the passage of this Act, and shall appoint a Director as soon thereafter as possible. The regular meetings of the Commission shall be held on the first Wednesday in May and the first Wednesday in November of each year in such place as the Commission shall determine.

SEC. 4. *Be it further enacted,* That it shall be the duty of the State Geologist, subject to the approval of the Commission, to organize and direct the work of the State Geological Survey in field and office; to determine the character, order, and time of publication of the reports of the survey, and to direct the prepara-

tion, printing, and distribution of the same; to arrange for coöperative work with the various Federal and State scientific bureaus where such work shall redound to the interest of the people of the State; to appoint such associates, assistants, and employees as may be necessary to carry out successfully and speedily the work of the survey; to procure and have charge of the necessary field and office supplies and other equipment, and supervise the acquisition, care, and distribution of the collections of the State Geological Survey; and to perform such other work as may be necessary to the successful conduct of the survey. He shall prepare a report to the General Assembly before each meeting of the same, setting forth the progress and condition of the survey, together with such other information as the Commission may deem necessary and useful.

SEC. 5. *Be it further enacted*, That the said State Geological Survey shall have for its objects and duties the following:

1. A study of the geological formations of the State, with especial reference to their economic products, including coal, oil, gas, ores, fertilizers, building stones, road-making materials, clays, cement materials, sands, soils, forests, mineral and artesian waters, drainage of swamps, streams, and water powers, and other natural resources.

2. A study of the character, origin, and relations of the soils of the State, with especial reference to their adaptability to particular crops, the maintenance of soil fertility, and the conservation and utilization of supplies of natural fertilizers.

3. A study of the road-making materials of the State, with reference to their character, distribution, and the best methods of utilizing the same.

4. A study of the occurrence and availability of underground water supplies.

5. An investigation of the forests, streams, and water powers of the State, with especial reference to their conservation and development for industrial enterprises.

6. A study of the swamp and other nontillable lands of the State, with reference to their reclamation for agricultural purposes.

7. A study of the physical features of the State, with reference to their bearing upon the occupations, physical welfare, and intellectual pursuits of the people.

8. The preparation of special reports, with necessary illustrations and maps, which shall embrace both general and detailed descriptions of the geology, topography, and natural resources of the State.

9. The preparation of special geologic, topographic, and economic maps to illustrate the structure, relief, and natural resources of the State.

10. The consideration of such other scientific and economic questions as in the judgment of the Commission shall be deemed of value to the people of the State.

SEC. 6. *Be it further enacted*, That the regular and special reports of the State Geological Survey, with proper illustrations and maps, shall be printed and distributed and sold as the Commission shall deem best for the interest of the people of the State and as said Commission may direct, and all moneys obtained by the sale of said reports shall be paid into the State treasury. The said Commission shall cause to be prepared a report to the General Assembly before each meeting of the same, showing the progress and condition of the survey, together with such other information as they may deem necessary and useful, or as the General Assembly may require; *provided, however*, that the Commission shall have the right to print and distribute said reports.

SEC. 7. *Be it further enacted*, That after having served the purposes of the Survey, all materials collected shall be distributed by the Director to the educational institutions of the State in such manner as the Commission may determine to be of advantage to the educational interests of the State; *provided, however*, that if deemed advisable, the Commission may first use such portion as may be necessary to establish a permanent exhibit of the natural resources of the State. On the completion or discontinuance of the State Geological Survey, the Commission shall cause all records, notes, books, reports, charts, maps, manuscripts, instruments, and other equipment and property of the survey to be placed in charge of a suitable custodian to be held subject to final disposition by the General Assembly; *provided, however*, that any field or other equipment which the Commission shall deem it undesirable to preserve may be sold as the Commission may direct and the money turned into the State treasury; and, *provided, further*, that the copies of the reports of the survey left on hand for distribution shall be distributed by the custodian in such manner as shall be for the best interest of the people of the State.

SEC. 8. *Be it further enacted*, That the said Commission is hereby authorized to enter into coöperation with the United States Geological Survey and other scientific bureaus of the Federal and State governments for the prosecution at joint expense of such work in the State as shall be deemed of mutual interest and advantage, and under such conditions as said Commission may deem to be for the best interest of the people of the State.

SEC. 9. *Be it further enacted*, That in order to carry out the provisions of this Act, it shall be lawful for any person employed hereunder to enter and cross all lands within the State; *provided*, that in so doing no damage is done to private property.

SEC. 10. *Be it further enacted*, That for the purpose of carrying out the provisions of this Act, fifteen thousand dollars ($15,000) annually for the years 1910 and 1911, or so much thereof as may be necessary, is hereby appropriated out of any money in the State treasury not otherwise appropriated, and the State Treasurer is hereby authorized to pay out the same on the warrants of the Comptroller upon the presentation of the proper vouchers by the Chairman of said State Geological Commission; *provided*, that the appropriation made herein shall not be available until May 1, 1910.

SEC. 11. *Be it further enacted*, That this Act take effect from and after its passage, the public welfare requiring it.

Passed April 30, 1909.

WM. KINNEY,
Speaker of the Senate.

M. HILLSMAN TAYLOR,
Speaker of the House of Representatives.

Approved May 1, 1909.

MALCOLM R. PATTERSON,
Governor.

ORGANIZATION OF THE SURVEY.

Under the terms of the bill, the Geological Commission consists of Malcolm R. Patterson, Governor of Tennessee, ex-officio Chairman; John Thompson, State Commissioner of Agriculture; R. A.

Shiflett, Chief Mine Inspector; Brown Ayres, President of the University of Tennessee; J. H. Kirkland, Chancellor of Vanderbilt University; and William B. Hall, Vice Chancellor of the University of the South. The commission held its first meeting on February 7, at which time an organization was perfected and a committee appointed, consisting of President Ayres and Chancellor Kirkland, to canvass the field and recommend a suitable man for the position of State Geologist. As a result of their recommendation, at a meeting held on March 16, the commission elected, as State Geologist, George H. Ashley, of the United States Geological Survey, at the time in charge of work in the eastern coal fields; and as Associate Geologists, Mr. Charles H. Gordon, Professor of Geology at the University of Tennessee, and Mr. L. C. Glenn, Professor of Geology at Vanderbilt University.

On May 1 the Survey began active operations. An office in the Capitol Annex, at Nashville, was made ready and properly equipped with the apparatus necessary for conducting the operations of the Survey. Plans for the first season's work were made, including many for coöperative work with the bureaus of the United States Government at Washington; assistants were selected and work begun.

PURPOSE OF THE SURVEY.

The purpose of the Survey may be briefly stated: The Geological Survey of Tennessee exists to obtain and publish accurate, definite, and unbiased information on the State's natural resources for the purpose of increasing the wealth and well-being of the State and its citizens through a larger and better use of those resources.

The Survey will be of direct value to the State in several ways: (1) By serving as the State's expert in determining the value, etc., of the State's present large holdings of mineral lands, or of any proposed additional purchases or sales; (2) by supplying the facts and information necessary to intelligent legislation concerning the State's resources; (3) by conserving the State's resources through leading to better methods of obtaining and using them; (4) by helping to bring into the State new capital for investment and the immigration of new citizens; (5) by keeping money in the State through aiding in the establishment of local industries to supply local needs, and by bringing additional money in by enlarging the output of farms, mines, and factories; (6) by leading to added sources of income for the State.

The Survey will be of indirect value to the State through its value to the individual citizens for whose welfare the State exists.

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It is of value to the landowner by showing what ores, minerals, rocks, or other resources underlie his land; their depth, volume, character, and value, and to that extent it affects the possible sale value of his land; and, second, by suggesting such use of his land as will make it yield the largest possible return. It is of value to those having capital to invest by supplying unbiased information upon which investments may be made or industries established. It is of value to transportation interests by increasing the volume of both crude and manufactured materials to be moved, through an increased production and an increased demand. It is of value to the purchasing public, which includes most of us, by reducing costs through the production in the State of things that must otherwise be obtained from without, and through increasing the supply of those things. It is of value to the man without work by increasing the demand for labor through the starting of new or enlarging of old industries.

In so far as the Survey may aid in the abating of the smoke nuisance in the cities, in obtaining cheaper light and power through a larger use of our water powers, in aiding and making effective plans for the drainage of the bottom lands, in converting poor farm lands into good farm lands, and in a thousand other ways, it may make it possible for all citizens to have more of the comforts and luxuries of life.

SCOPE OF WORK.

The Survey is primarily a bureau of information on certain subjects. This implies, first, the collecting of the information; second, the study, systematizing, filing, or preparation of that information; and, third, the supplying of that information.

The subjects on which the Survey is to serve as a bureau of information have already been outlined in Section 5 of the Act under which the Survey is established. They may be grouped as follows:

1. General geology, mineralogy, physics, and chemistry, so far as they relate to the natural resources of this State.
2. Geography of the State.
3. Metals and their ores.
4. Fuels and fertilizers.
5. Structural materials and materials used in the arts.
6. Water and water power.
7. Soils.
8. Reclamation of land.
9. Forests, roads, etc.
10. Miscellaneous materials and products.

The scope of the work may be suggested by running over briefly the subjects just listed, pointing out a few of the lines of information about which experience has shown questions are asked.

General Geology.—General geology tells what the rocks are composed of, how they were formed, how they came to be found in their present position, how they have been changed from their first condition, what animals and plants lived at the time they were deposited, the cause and action of earthquakes, mountain building and other geological activities, the history of the earth's surface, of its climate, and a thousand other questions. Sometimes questions are asked about these things for themselves by those desiring to know something of the why and wherefore of the world about them. More often a knowledge of those things is desired because such a knowledge is absolutely essential to any scientific study of the economic products of the earth. It is a matter of common knowledge that the valuable ores, minerals, rocks, fuels, etc., are not uniformly distributed in nature, nor, on the other hand, do they occur with entire irregularity, or as though by mere chance. The experience of men all over the world, when brought together, shows certain relationships between the occurrences of these materials and the occurrence of other materials, or of other conditions and forces. These facts, when all brought together, make up the science of geology.

When, for example, the geologist draws a line around a certain area in the Cumberland Mountains and says, "Within this line there is, or may be, bituminous coal, but outside of it there is none," he bases his statement on a whole volume of "theoretical" information. Thus it implies that he knows the age of the rocks within that line and of all the rocks outside of that line, involving in turn an intimate knowledge of the fossils in these rocks through which their age is determined, and the general meaning and relations of these fossils. But it implies also that he knows the approximate age of every workable bed of coal in the world, and the fact that experience has shown that no workable coal ever has been found in the rocks of the early ages to which the rocks outside of the line he has drawn belong. So, too, when he draws certain belts across and around the State, and says, "If you are interested in zinc, look within the areas indicated, but not outside," he is again basing his statement on the experience of men in mining zinc everywhere and on his knowledge of that experience. To-day there are several thousand geologists, mining engineers, and others who are constantly studying the occurrence and character of the deposits of

ores and other economic minerals and rocks and describing them in hundreds of reports and journals that are printed each year. But there are, in addition, others who devote much of their time to bringing together all of these facts relating to any one subject and drawing therefrom general conclusions based on experience from all over the world. Those general conclusions form the *science* of geology. It is this *science* that the trained geologist must know and must apply if his work is to have any value to the State employing him.

On the other hand, the geologists and mining men, not only in this State, but all over the world, expect that, with the establishment of a Geological Survey in Tennessee, they in turn will receive from that Survey descriptions of all the conditions surrounding the occurrence of the various economic deposits of this State, forming a contribution by the State to the general science of geology. It is, therefore, planned that, in addition to the so-called "theoretical" geology which may accompany the detailed description of ores or other deposits, there may be published from time to time general theoretical papers that bring together all or a large part of the facts in this State along such lines, as: the description of fossils, the structure or "lay" of the rocks, of the origin of various deposits, of the extent and history of any group of rocks, or of any part of the present surface of the State, and of many other similar subjects.

Fortunately, for the rapid prosecution of the present work, a large share of the theoretic geology of the State had already been studied out and published by Troost, Safford, Killebrew, Hayes, Campbell, Keith, David White, Glenn, Ulrich, and others; but in the detailed work to be done by this Survey many other problems will doubtless be met with and will have to be worked out and published as a basis for future investigations.

Geography.—The National and State Geological Surveys have always been looked to for the preparation of maps showing the geography of their respective domains, as well as the geology of its rocks and deposits. This work may take on several forms.

One phase of the work is the setting of meridian lines. Just as the geologist, in his travels through the mountains, is constantly being asked to make on the floor of some woodman's porch a north and south line to serve as a noon mark in lieu of a clock, so the Geological Survey is looked to by county surveyors to establish at the county seats accurate meridian lines. It is well known that the compass points not to the north pole, but to the magnetic north pole, and that this magnetic north pole is constantly shifting from year

to year, so that the land line described by the points of the compass in 1850 will not agree with the same points of the compass in 1910. In securing these meridian lines, the State Survey will coöperate with the Coast and Geodetic Survey.

The making of maps will form no small part of the work of the Survey. These will range from small scale maps of the State, showing only the county seats, to large scale detailed maps of small areas, showing all of the roads, trails, houses, streams, the exact shape of the hills and valleys, the location of the mines, quarries, springs, etc. Some of the more detailed maps will show every five-foot change of level in the ground. These maps may be published simply as geographical maps for the use of engineers, surveyors, travelers, landowners, prospectors, or other people; or they may form a basis on which are placed facts about the geology or soils or timber, the roads, water supply, markets, or any one of those things with which the Survey is to deal.

High-grade, plain, geographic maps, showing the topography, are much studied and used, where they exist, for the location of steam and electric railways, of State and county highways, of schools, telegraph and telephone lines, for the laying of water pipes, aqueducts and sewerage systems, for the drainage or irrigation of land, for the position of county and township lines, for selecting the best routes for automobile tours or tramps, in planning maneuvers of the National Guard, in connection with the purchase or sale of land, in gaining exact knowledge of the country, elevation of places, distances and directions between places, and for a multitude of other uses.

In the early days the geologists made their own maps as they went, and in reconnoissance work that is often still necessary; but where detailed work is to be done, requiring detailed topographic maps on which to publish the geologic results, it has been found much more economical to train men for the specific purpose of map making. To obtain such maps, there is required accurate primary and secondary triangulation, traverses, and leveling work. The preparation of such maps is expensive, costing from $4 to $50 per square mile, according to the scale of the map and the character of the country. It has been the practice of most of the States needing such maps to ask the coöperation of the Topographic Branch of the United States Geological Survey, which stands ready within the limits of its funds to make such maps where requested, the State and national governments sharing alike in the cost of the field and office work, but the national government assuming the entire cost

of engraving and printing the maps. At present forty-eight per cent of Tennessee, mostly in the eastern and central parts of the State, has been covered by such mapping, which, in most cases, has been followed by geologic mapping. The early maps, both topographic and geologic, were done rapidly and at small cost. Gradually the grade of such work has been improving, until to-day the United States Government frankly labels later editions of the early maps as "reconnoissance" maps. As the grade of geologic work has risen, it has been found necessary to have better and better topographic maps in order to adequately represent the geologic facts obtained. This has continued until to-day the older topographic maps are entirely inadequate for the representation of geologic facts as obtained by modern methods. The first step in geologic work has, therefore, been the securing of adequate topographic maps.

Fortunately, for the beginning of the new work in Tennessee, a few of such up-to-date topographic maps have been made in this State within the last few years. The recent topographic maps on hand will suffice for the geologic work for the first season or two, but soon active steps must be taken to secure similar good maps of other areas on which the Survey desires to do work. Efforts to secure additional modern topographic maps in Tennessee by the United States Geological Survey will be made.

The present funds of the Geological Survey of Tennessee do not warrant seeking such coöperation, except to a very limited extent. It is hoped in the future that more funds will be available for that specific object.

Metals and Their Ores.—In their occurrences the ores of the metals may be divided into two classes: those which occur as original bedded deposits, as the Clinton iron ore of Tennessee, and those which, in a sense, are secondary in their occurrence—that is, have been brought together after the deposition of the containing rocks by segregation, replacement, or otherwise, and occur in veins or other irregularly shaped deposits. Deposits of the first class would be studied very much as are the beds of coal, as described in the following section. In the study of ores of the second class, the Survey will attempt to find out for each of the metals just what formations may contain its ores, to delimit these formations on the map so as to show in just what parts of the State the ores of that metal may or do occur. Then it will try to determine under just what conditions or combinations of conditions the ores do or may occur, and to point out where these conditions exist, using large-scale detailed maps for the purpose. This will involve a study of

the occurrence and origin of all of the known deposits in the State, combined with a knowledge of similar deposits elsewhere. In brief, the aim will be to study the occurrence and origin, the character, extent, and value of all of the known deposits in the State of the metallic ores, first, in order to secure or extend their development; second, to point out just where else they may occur and how they may be recognized; and, third, to tell how they are mined and marketed and to what uses they are or may be put.

Fuels and Fertilizers.—Most fuels and fertilizers have, in common, an origin from living forms, either plants or animals, and are deposited in beds often of considerable lateral extent, but of small vertical extent. In many ways the same methods will be followed in tracing phosphates as in tracing coal beds.

Thus, in studying the coal of the State, the Survey will seek to determine the exact limits of the coal field, the series of rocks in that field, the number of coal beds and their position in that series of rocks. Of each bed it will try to determine the average thickness and the variations of thickness from place to place; its analysis, quality, purity, freedom from shale partings, binders, etc.; the character of its roof, floor, etc., as affecting its workability; its distance above or below some conspicuously outcropping rock, so that, by reference to it, the coal bed may be found; the position of the bed in the hill; its probable extent and character in any direction or under any given area; its dip or lay, giving very closely its exact depth at any point; the total tonnage that should be recovered from it; the methods of working, preparing, and marketing the coal; and, finally, the various uses to which it can be put, and especially the more recent advances that have been made in the use of coal. In this work, again, it will be attempted to show on the map accurately the position of each principal coal bed, so that any one with the map in hand could go at once to the position of its outcropping and, by prospecting, determine its presence and local character.

The occurrence of oil does not lend itself so readily to accurate description and forecast. It is a common idea outside of the oil fields that the discovery of oil is the result of hunting over the surface for oil seepage or other visible evidence of oil. It is true that in a few cases the discovery of an oil seepage has been followed by striking oil in a well bored on that evidence; but it is probably also true that not one successful oil well in a thousand has been located on such evidence; while, on the other hand, of all the oil wells drilled on such evidence, probably four-fifths have never paid back the cost of drilling. The successful oil men have always followed

" leads " consisting of lines of structure, water conditions, etc. Oil, like water, runs down hill, and, if it is not associated with water, will accumulate in the lowest part of a fold in the rocks containing it. If it is associated with water, it will, on account of its lightness, tend to rise to the top of the water, which may be along the top of the fold if the rock is full of water, or along the flank of the fold if the rock is only partially saturated. These are a few of the most simple elements of the many that control the occurrence of oil. Within certain broad limits it is possible that oil may be found anywhere in the rocks. Actual experience in any given territory shows that certain beds are more likely to contain oil than others, and under certain conditions of structure, water content, and other factors.

It is the office of the Geological Survey to seek to determine what beds of rock have been shown, by experience, are most likely to contain oil and gas, and under what conditions, and to determine where else those beds occur under those conditions in this State. In this work coöperation with the experts of the Federal Survey will be sought, in order to gain the advantage of their intimate knowledge of the conditions holding in the large developed oil fields of the country.

Phosphate rocks form one of the most valuable assets of this State. Work already done on them has shown that they occur at a few very definite horizons or as secondary deposits made by the weathering of the original deposits and the redeposition of the phosphates. It will be the aim of the Survey to determine accurately just what the limiting conditions are under which the phosphates of this State occur, and then to trace, in detail, the occurrence of these conditions, testing the rocks chemically in the field as the work progresses, and showing the position of the rocks that are found to be phosphatic on detailed maps.

Structural Materials and Materials Used in the Arts.—Under this heading will come a large variety of substances, some of them of the first rank in importance, others of only minor importance. Thus it will include marble, limestone, cement rocks, lithographic stone, sandstone, clays, shales, slates, barytes, pyrites, fluor spar, whetstone, glass sand, salt, nitre, silica rock, and many other rocks and minerals of greater or less value. For the present purpose it will suffice to point out some of the lines of study connected with one or two of the substances listed, as, for example, marble and clay rocks.

Marble is a crystallized limestone suitable for fine structural work. The limestones are among the regularly bedded rocks, and their general outcrop has already been mapped. It is probably true that

only a few of the many beds of limestone in this State are ever found in the condition of marble. It will be the purpose of the Survey to determine which of these beds contain marble and to follow their outcrops wherever they occur in the State, examining the rock at every exposure, and showing by detailed maps just where they appear to be of sufficiently high grade to serve as commercial marble. This will include a detailed study of the stratigraphy or position among the rock strata, of all of the known marble deposits, of the fossils by which these particular beds may be recognized, and, afterwards, the detailed tracing and mapping of these beds with close scrutiny for marble.

The clay rocks, from which bricks, tile, terra-cotta, China ware, etc., are made, occur in the earth as regularly deposited beds of clay or shale, or they occur as surface deposits, having been derived from older rocks by decomposition and water transportation. Where they are regularly bedded, it is possible to determine just their stratigraphic position in the rocks. The preliminary work will consist of a study of the developed deposits and the determination of their position, character, etc., and that will then be followed by the detailed tracing, testing, and mapping over the State of the beds that experience or examination shows to contain deposits of commercial character.

The surface deposits are more irregular in their character and disposition, but, aside from those found in the bottoms along streams and rivers, will usually be found associated with certain rocks under certain conditions. The Survey will seek to discover what these associations and conditions are, and then to trace and map wherever these associations and conditions exist.

Water and Water Power.—The lines of inquiry in regard to water (aside from rainfall, which is looked after by the National Weather Bureau) deal with run-off of the surface streams, conditions affecting it, and the results under different conditions, as well as possible modifications of the present conditions so as to give better control of the run-off; surface springs, both clear and mineral; underground water supplies, artesian well areas, water-bearing levels or strata; possible sources of water power, with minimum and maximum derivable power, and the problem of its use and transportation; navigation of rivers, water for irrigation, etc.

Soils.—After all is said and done, the soil is the earth's great storehouse, furnishing man with his most fundamental necessities —food, clothing, and shelter—and, when properly cared for, continuing to do this from century to century with undiminished gen-

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erosity. The soil presents two problems: First, the maintenance or conservation of its physical and chemical substances; second, the increase of its efficiency to the highest possible point. In a large measure, the soil is a factory or place in which raw materials are worked up into finished products. Essentially it is composed of insoluble sand or other substances that do not enter at all into the finished product. Into this factory come the raw materials—some to be stored until needed, and some, as the water, to come and go, except as they are used. The conservation of the soil is mainly an engineering problem, and is considered under the next head. The increase in the efficiency of the soil is a subject of almost unlimited possibilities. It will be the aim of the State Survey, working in conjunction with the other departments already in the field, to make a detailed study of every type of soil in the State; to learn its origin, physical structure, and chemical food contents; to determine to what crops or use it is best adapted in its present condition; to see if its physical condition cannot be improved by some different handling, or by tiling, or in some other manner; to see if it is not lacking in some essential element; to learn from the best farmers now living on that soil what its possibilities are, sometimes noting the experience of farmers from other States on similar soils, or the result of the experiment station studies. These studies having been made largely with the aid of the agencies already in the field, it will be the special province of the Geological Survey to trace, in detail, the extent of each type of soil and to prepare maps of the same. Here again, as elsewhere, arises the necessity for detailed topographic maps, if this work is to be done in sufficient detail to be worth while.

Conservation and Reclamation of Lands.—While it must needs be that the hills shall be worn down and carried away to the sea, it is of the uttermost importance that this movement should be as slow as possible. As long as the soil is washed from the hills no faster at any point than the forces of weathering can break up the rock underneath into new soil, there will be no permanent harm done; but when it exceeds that rate, the erosion does damage that is likely to grow worse with time, until land that should have been fruitful for ages becomes barren for all time. Again, if this material washes into the streams faster than it can be carried off, it will serve to produce floods on the bottom lands and to hinder navigation. The problem of the conservation of soils and the prevention of hillside wash will, therefore, form one subject of study by the Survey.

Steps are actively being taken for the reclamation of the bottom

lands of parts of West Tennessee. This is being done by districts organized under the drainage law of 1909. (See Bulletin No. 3, Part C.) These drainage districts are usually organized to cover the portion of any valley lying in one county. This may include the whole valley. Usually it will not. Experience, too often disastrous, has shown the necessity that all drainage work be planned with a knowledge of all of the factors and conditions in the case if the work, when completed, is to be efficient and economical. That it may be both, requires a knowledge of many factors that it may be difficult to get in any one district, or which have already been obtained in some other district. It is, therefore, felt to be the special province of the Geological Survey in aiding in this work to first take such parts of the work as are general in their nature, bringing to the districts such necessary data as that on rainfall, run-off, etc., carrying on observations and experiments where necessary and drawing on the experience of other districts in this and other States where possible.

Again, where there are several drainage districts on the same stream in different counties, it is most desirable that there be some way of coördinating the plan of construction in one district with that in the districts above and below. Otherwise, as has sometimes happened, the construction in one district may follow a different plan from that in the other districts, resulting locally in a worse condition than at first—endless lawsuits, injunctions, etc. It is, therefore, the hope of the Survey to lend its friendly aid, as far as possible, in securing coördination of plans along any one stream.

The work will include not only reclamation of land rendered nontillable because of flooding, but the reclamation of lands from which the soil has been allowed to wash away, or which, for any other reason, has been allowed to become barren and nontillable.

Forests, Roads, Etc.—The forest, like the soil, is one of those things that, if properly cared for, will continue itself indefinitely. It is, however, usually treated as one of the things to be exterminated. Over large areas the forest has had to give way to fields and pastures, but there still remain large areas not suited to the cultivation of crops or the raising of cattle. Too often from these areas the native growth of timber has been removed and no effort made to grow a new crop of timber. In the past it has been the general tendency to look upon timber as one might upon rabbits, or bears, or buffaloes—as a part of nature's "wild stuff," to be gotten while it lasts; for when it is gone, it is gone. Of late years there has been a growing appreciation that just as we no longer

think of depending on wild strawberries or wild rice for our supply, so will we not much longer depend on wild timber for our supply. With that appreciation is a growing demand for information about the proper way to cultivate timber; the general conditions of soil, topography, and climate best adapted to timber raising; the kinds of trees best adapted to any given soil, or other factors, etc. As it is at once recognized that the raising of timber will be vastly easier where there is already some of the desired timber on the land, there will be three lines along which inquiry will be made: First, the facts concerning the present supply of timber—its location, kinds, amount, etc.; second, how to conserve the present forests so as to make them a source of future and continuing supply (how many lumbermen now think of selecting and preserving seed trees, as the stockman will preserve and care for his brood stock?); third, a reforestation of areas better adapted to the raising of trees than of anything else and that never should have been deforested. These are the lines along which the Survey plans to gather and publish information.

What the railroads have been in the building up of the country at large, good roads may be in the building up of smaller divisions of the country. There are three factors of cost of farm products or lumber—cost of production, of transportation, of distribution. Every dollar saved in any of these three points is a dollar earned. If it costs the farmer twenty cents a bushel to haul his wheat to market over a poor road and ten cents over a good road, and he raises one thousand bushels, the poor road has cost him just one hundred dollars for the moving of that one crop alone.

The Geological Survey hopes to be able to aid in the building of good roads in at least three ways: First, through the detailed topographic maps, which will aid in showing the amount of rise or fall a road will have to have in going from any one point to another, and then showing where it can be placed so as to keep within the maximum grade decided on, for as the strength of a chain is determined by its weakest link, so the hauling efficiency of a road is measured by its steepest grade; second, it may help by locating, testing, and mapping materials suitable for the building of roads; third, in connection with the last in coöperation with the Good Roads Division of the Federal Agricultural Department, it may point out and illustrate methods of road building, use of materials, etc., in addition to what it may do by publication of road maps and general information about roads.

WORK OF THE SURVEY.

The work of the Survey will fall under the following heads:

1. Field work.
2. Office work.
3. Laboratory work.
4. Exhibit and educational work.
5. Publication.

Field Work.—The field work will vary in character and methods in accordance with the objects sought. While the great bulk of the work will consist of detailed studies and mapping, in most cases this will have to be preceded by preliminary studies. These preliminary studies will be made at the points at which any given mineral resource is or has been developed. Such work will consist of personal visits to the various active plants by some member of the Survey, the examination and measurement of the deposits to determine their origin, age, relationships, mode of occurrence, size, quantity, quality, character, methods of extraction, the process of smelting or recovery, etc. These reports will usually be accompanied by sections and maps. The facts obtained will be of value in showing the present condition of the industry involved, the kind of material used, how it occurs, etc. These facts will also be used and be necessary for determining the condition of occurrence on which the future detailed studies and mapping will be based.

In some cases this work will consist of excursions to examine some locality at which it has been reported there occurs some ore or mineral of wide interest or value; or the work may be a reconnoissance study of all of the known occurrences of some resource, as of coal, oil, or phosphate.

The detailed work will be of two kinds—areal work and the tracing and study of some one resource. In many cases the areal work will be done in connection with the study of the principal resource of that area. In the areal work a set of traverse lines is run all over the area, some of them following the streams and gullies, some the roads, some the hillsides, following along the outcropping of a bed of rock or mineral, others filling in the spaces between, as it may be necessary in order to complete the mapping or to examine some prospect or mine. As these traverses are run a record is made, by means of a double system of notes on field maps and in notebooks, of every geologic fact, including a graphic description of every outcrop of rock, its thickness, color, grain, bedding, dip, etc.; if possible, its stratigraphic position is determined

or noted, if known; fossils are collected wherever necessary; samples and specimens are collected for analysis, study, or exhibit. The notes are made in such a way as to show accurately the horizontal and vertical relations of all of the facts collected. In this way, no matter how fragmentary the facts may be, they are fitted at once into their proper place, and, as the work progresses, data lacking at one point may be supplied from some other point. Gradually it becomes possible to fill in the lacking information to a greater or less degree, just as it becomes possible to fill in a picture of a partially set up puzzle, even though most of the pieces are still lacking, for, wherever these traverses may go, all are so tied together that the relations of any fact obtained on one becomes obvious to all of the facts on any other line.

If beds or deposits of known or suspected economic importance are encountered, they are examined in more minute detail following certain more or less well-defined lines of procedure; if desirable or necessary, efforts are made to secure better exposure of some economic deposits. Wherever possible, the information obtained directly by the geologist in the field is supplemented by reports of drilling and prospecting made by mining and prospecting companies, by observations made by those residing in the district, or by any other data obtainable.

In the detailed study of any selected economic resource, all of the conditions of its occurrences, its character, quantity, etc., are determined by the preliminary study. The main work will include the detailed tracing of the occurrence of these conditions wherever the general conditions make it possible for them to exist.

From what has just been said and from what was said under "Scope of Work," it is evident that all of the detailed mapping will require detailed topographic maps. It is not enough to say that such and such a coal bed outcrops within a mile to the east of such and such a town, or that it underlies between one hundred thousand and two hundred thousand acres. Its outcrop should be shown within at least a few hundred feet horizontally and a very few (twenty) feet vertically (generally much nearer); the area it underlies should be known within at least a few hundred acres. It will not always be possible to secure such accurate results, but results as close or closer will always be aimed at.

To do detailed work in the oil and gas, phosphates, soils, cement work, clays, and most other materials, will require the same detailed topographic base maps as in working the coal or iron, if the results obtained in the field are to be adequately represented.

It is hardly necessary to outline all of the various methods adopted in the field work where various results are to be secured. The methods used by the several Federal bureaus, which will cooperate in topographic mapping, soil mapping, oil and gas work, forest mapping, etc., have been described in detail in publications issued by these several bureaus, and in many cases will be given in connection with reports on their work to be published by this Survey in the future. Different methods from these described will have to be used in the study of road materials or underground waters or water powers or of many other such subjects.

Office Work.—The office work will consist, first, of the correspondence and other work necessary in the planning and carrying on of the work of the Survey; second, in the identification of specimens sent in or brought in; third, in supplying information about any of the subjects with which the Survey is concerned, especially as to the location of deposits of desired materials, etc.; fourth, the collection and tabulation of information about mines, drillings, etc., partly to meet the demand under the third clause and partly in preparation for future field work or publication; fifth, the working up of the material obtained in the field and the preparation of the reports; sixth, the study of the literature relating to the natural resources of the State, and the preparation of preliminary circulars of information and of a bibliography of the literature.

A few words of further explanation may be made of some of the lines of work just listed. One of the first lines taken up is that mentioned last. In the course of the prosecution of previous National, State, and private geologic and other surveys and studies, a large amount of valuable information has already been gathered. This is scattered in a great many publications of many kinds, some of which are out of print, many of which can be obtained only with difficulty, and in most cases the information on any one subject or about any one locality is scattered through a dozen or a score of publications.

As a preliminary to the reports on the detailed studies to be made by the Survey, many of which cannot be ready for some years, preliminary circulars of information will be prepared as rapidly as possible, drawn from all sources of information available at the time. This information must necessarily be gathered for the use of the Survey, and, if published in brief, summarized form, will serve for answering inquiries until the reports of the detailed work become available.

The office work of preparing the field material for publication

will vary greatly according to the character of the work. Where the subject of the study lies entirely at the surface, the report may consist simply of a transcript of the field notes properly arranged, condensed, and edited, accompanied usually with a map, and the time involved is usually short as compared with the time required for the field work. More often the notes themselves are used as the basis for certain general conclusions, and these must first be reached, often involving complicated computations, reaching conclusions that must then be interpreted in terms of the map, etc. In still other cases dealing with materials almost or entirely underground, as with the coal, oil, gas, and other such resources, the data is apt to be mostly of such indirect character, and often so incomplete that the working up of such data is a long, slow job, involving endless plotting out of well records, the projecting of surface dips to the depth of the deposit being studied, with all of the necessary calculations to allow for the differences in the dip due to the changing thickness in the intervening beds; the constant application of the law of probabilities, based on the known conditions occurring elsewhere in developed territory. Where doubt exists as to the identity of any bed outcropping at the surface, it may be necessary to make a series of possible assumptions and carry the full set of calculations through with each to determine the bed's most probable identity and the probable depth, etc., of the subject of study. This statement is given in explanation of the seeming long delay that experience has shown is apt to ensue between the field work and the appearance of the report wherever these underground deposits are concerned.

The collection and tabulating of data to-day forms no small part of the work of the office. The success of a given piece of field work often depends on having copies of records of wells or prospects. If the collection of these is left until the field work is to be done, too often it is impossible to get all of the records. Experience has shown that the best way is to get them when they are available. Having gotten them, they are of no use unless properly classified and filed, so as to be available whenever wanted. The same thing is true of a large amount of data about the mines and quarries, of analyses, of the results of prospecting, and of information received through correspondence or from office callers. The Survey will employ the usual business methods in filing and caring for this material.

While the published reports and circulars will be depended on in the main in answering inquiries, the Survey always stands ready

to supplement the reports with any personal explanation that may be necessary. It is intended that in any case the report will give all of the information possessed by the Survey (except confidential data); but the writer realizes that, in applying the conclusions of a report to any particular locality, it is not always easy to see or understand just what the result of the application will be locally.

The identification of specimens brought or sent to the Survey has always been recognized as one of its legitimate functions. While it is true that it is only rarely that specimens so received by the Survey have any wide interest or value, and that a large share of the specimens prove to contain only mica or pyrite (fool's gold) or other substance that is of no value in the form in which it occurs in the specimen, yet it is as much the function of the Survey to prevent the useless expenditure of money on noncommercial projects as to encourage its expenditure on other projects.

The correspondence and other work necessary to the planning and carrying on of the work of the Survey may be judged by the success or otherwise of the work itself.

Laboratory Work.—In accordance with the general plan of not duplicating plants in existence or work already being done, the Survey does not plan to establish elaborate chemical or physical laboratories at this time. On the other hand, it plans to make use, as far as it may, of the laboratories already in existence, such as those of the State Chemist, the State Agricultural Experimental Station, the new Federal Bureau of Mines, and the several laboratories of the Federal Agricultural Department. In this way it will be possible not only to avoid the large expense of equipping full laboratories, but in many cases it may be possible to secure coöperation in the laboratory work so as to obtain a division of the expense.

In most cases it will be possible to secure such coöperative laboratory work only where the work being done is of interest to the coöperating bureau or department. There will doubtless arise from time to time many minor chemical questions which will make it desirable that the Survey be equipped to make simple qualitative tests in the prosecution of its work, and it will be so equipped. In another part of this bulletin a statement is made of the Survey's policy in regard to doing analytical work for private parties.

In addition to the chemical analysis of the various materials constituting the resources of the State, there are to-day many experiments being carried on looking to the better utilization or preparation of the mineral resources of the State. The Technologic Branch of the Federal Geological Survey, which now forms part of the new

National Bureau of Mines, has for several years been carrying on extensive experiments in the better utilization of coal and other substances, and there are to-day a number of experimental laboratories, such as that connected with the University of Illinois, that are doing work of a very high grade. While this Survey does not anticipate undertaking any such work at this time, it will plan to keep in close touch with results of such work being carried on elsewhere, and to call attention to such results through the medium of its reports wherever such results have a direct bearing on the utilization of the resources of this State. In addition to that work, it will attempt to follow the practical application of any of those suggested better methods as they may be applied in this State, or of any other experiments that are being carried on within the State by the producers or large consumers.

Success in the business world to-day is spelled in good management and good methods. The first is mainly a matter for the individual to work out for himself, but the second point comes as a matter of experience based on experiment. In the mining, metallurgy, or preparation and utilization of nature's resources, there is much to be learned.

To take the case of coal again. In many districts but little more than one-half of the coal in the bed is obtained by mining; in others ninety-five per cent of the coal is gotten. It has often happened that by some change in the methods of preparing the coal for market, a gain of five per cent or ten per cent may be made in the amount of marketable coal obtained, or in the price obtainable for the coal as a whole without the mining of an additional ton. The ordinary steam engine does not obtain more than five per cent to ten per cent of the power available in the coal. Power equipments are now being built that obtain from twenty per cent to thirty per cent or more of the coal's power from the same amount of coal by first converting the coal into producer gas and the use of that in a gas engine. Indeed, it seems possible to look forward to a day when all of the power being used in at least Eastern and Middle Tennessee that is not derived from water power will be generated at the mines in the coal fields and transmitted electrically to where it is to be used. The smokeless combustion of fuel is another item of large interest to the cities.

Exhibit and Educational Work.—This work will consist, first, of the collection of specimens showing the various ores, minerals, rocks, and fossils occurring in the State, with specimens illustrating the several steps in the processes of refining, smelting, screening,

or otherwise preparing for market; second, of the preparation of a State exhibit properly labeled and displayed; third, of the preparation of suitable exhibits of the State's resources at the expositions that are held from time to time; fourth, of the preparation of school collections from the surplus material collected by the Survey to be distributed to such schools of the State as give courses along the lines of the Survey's work; fifth, the preparation of "popular" bulletins in untechnical language of the origin and mode of occurrence of the deposits constituting the mineral resources of the State, of the history of the mountain ranges of East Tennessee, of the Cumberland Plateau, of the basin of Middle Tennessee, of the Mississippi Valley, of the State's caves and other objects of special interest, of the nature and development of soils, of the simple principles of erosion and deposition, etc.; sixth, of the giving of talks and lectures by the State Geologist and other members of the Survey on the State's resources or geology; seventh, of the preparation of special magazine articles on Tennessee and its resources for outside popular and technical magazines, calling attention to the opportunities the State offers for business enterprises or profitable employment, the beauty of its scenery, its advantages as a place of residence, its educational, climatic, and other advantages.

Publications.—The results of the Survey's work are to be published as bulletins, to be issued as rapidly as they are prepared, and numbered serially. In the case of some of the first bulletins, which will be largely a review and gathering together of our present knowledge of the geology and resources of the State, the bulletin may consist of several distinct papers, and a small edition of the individual papers will be issued as fast as ready to supply the demand for such information. The individual papers will be treated as preliminary papers or as "circulars of information."

As the cost of publishing the bulletins must come from the appropriation for the Survey, the editions will be kept as small as possible, and every effort made to distribute them with care in order that they may fall into the hands of those having a real interest in the subjects treated. For that reason no widespread distribution of the bulletins will be made as they appear. They will be sent free to libraries, educational institutions, the press, State officials, foreign officials connected with geology, mining, agriculture, and forestry, and to such persons as are in active coöperation with the department or have rendered tangible service in the work in hand. Notices will be sent to such as by inquiry or otherwise have expressed an interest in the particular subject treated, and they and

any other persons interested may obtain copies of the bulletins upon request by inclosing necessary postage.

In many States it has been the experience that long after the edition of a report has been exhausted there continue to come requests for that report, often from persons having large interests in the matter treated of, or who are considering local investments, and the fact that no copies are to be had may result in a distinct loss to the State. To meet that difficulty, five hundred copies of each edition will be reserved for sale at the cost of publication. This small supply should serve to meet the need of late comers, who, if they have a real interest in the matter of the report, can hardly object to the small cost necessary to obtain the information they desire. In accordance with the bill establishing the Survey, all funds obtained in this way are returned directly to the State Treasury.

As many of the Survey's bulletins will be small, and as it is often difficult in a large library to properly care for small bulletins, the plan will be tried of reserving a part of each bulletin unbound until the end of the year and then to bind all these parts together into a library edition. Under this plan the distribution of bulletins to the libraries will not be made until the end of the year.

In subject-matter, the bulletins will fall into five classes:

A. General Information.

This will include bulletins that contain such information as would be desired by a citizen having only a general interest in the subject in question, or by people outside of the State making general inquiries. It will include bulletins on broad subjects involving the State as a whole, and general and preliminary papers on such large subjects as coal or iron (in which the detailed descriptions will fill many bulletins), where they will be used until the study of any given area is completed.

B. Detailed or Local Descriptions.

This will include the bulletins giving the results of detailed studies of a given deposit or of a limited area, as of a county. The bulletins on the several counties will be included under this head. As requests are mainly for information relating to some subject rather than to some county, as such, the detailed studies of the counties will be taken up in connection with the study of the principal resources they contain. Preliminary papers on the various counties may be issued to meet immediate requirements.

C. Technological Bulletins.

These bulletins will deal not with the geologic descriptions of deposits, but with the technique of their use or mining, or other mat-

ters of that kind, such as the smokeless combustion of coal, the electrical transmission of water power, the prevention of hillside wash, etc.

D. Educational and Scientific Bulletins.

These include bulletins describing the minerals or rocks of the State, its stratigraphy, paleontology, physiography, etc.

E. Progress Reports.

This will include the biennial administrative report of the director of the Survey to the State Legislature, reports of partial results of long-continued investigations, etc.

COÖPERATION.

In formulating the policy of the Survey, it has been the idea of the State Geologist that the desire of the people of Tennessee was not so much to build up a strong State Survey as to secure certain results with the least possible delay and at the smallest possible cost. The experience of many of the States has shown that by coöperating with the Federal bureaus, which are thoroughly equipped with the necessary instruments, with specialists who have been trained by years of work, ready to take the field at once, that any piece of work can be done with much less cost to the State than for the State to attempt to do that work for itself.

Accordingly coöperative agreements have been entered into with several branches of the Federal Geological Survey and with several of the bureaus of the Agricultural Department, in addition to coöperative arrangements with several of the other departments of this State. Under these coöperative agreements, as a rule, the work is done under the direction of a government expert, the expense and the results being shared equally. In many cases the Federal Government pays salaries and the State Government pays the field expenses, which, as a rule, will not amount to as much as the salaries. In some cases, as in the coöperation with the United States Geological Survey, two types of reports are prepared—an economic report, which goes to the State, and a scientific report, which is published by the national government. As a rule, the State Survey determines the amount and grade of work to be done, and where it is to be done, provided such proposed work will fit into the general plans of the Federal bureaus concerned. So many of the States have entered into coöperative agreements with the bureaus of the Federal departments that the funds of some of these Federal bureaus go largely into coöperative work, so that

States not coöperating have very little work done in them by these bureaus.

Some of the advantages to the State with these coöperative agreements may be cited: In the first place, the amounts of such work done in this State and made available to its citizens is nearly twice as large as the State Geological Survey could do alone; in the second place, the State reaps the advantage of having the work done by trained specialists without having to build up or train a corps of high-salaried men for possibly small amounts of work in each of their lines; in the third place, the national bureaus usually have facilities for engraving and printing the maps showing the results of the surveys, and transfers of such maps may be obtained by the State for its own use at a small fraction of what the engraving costs; in the fourth place, many of the geologic and other features occurring in this State are parts of large provinces extending over many adjacent States, and the members of the Federal bureaus bring to the work in this State a knowledge of the conditions in other States in which the same formation is found.

There are, of course, many phases of work in which the State Survey has a vital interest, in which the Federal bureaus do not have an interest, and in which they will not, therefore, coöperate. In many respects their interest is more of a general nature than a purely economic, whereas the State Survey is primarily economic and only secondarily deals with matters of general interest. The State Survey is, in a sense, an advertising agency for the State's resources, and in that line naturally the Federal surveys can take no part. There are many types of reports that must be gotten out by the State Survey in pursuance of the particular objects it has in view, in which it cannot coöperate with the Federal surveys.

In general, in planning coöperative work, the attempt is made to secure such coöperation for the most detailed and expensive lines of work, while reconnoissance work and other studies dealing with purely local matters will be taken up by the State Survey.

For the first season coöperative agreements have been made with the Geologic and Topographic Branches of the United States Geological Survey, and with the Bureau of Soils, the Public Roads Division, and Drainage Investigations of the Federal Department of Agriculture, and tentative plans have been made with several other bureaus and departments for coöperative work in the future. As a rule, the Federal bureaus pay salaries and the State pays expenses, so that its money does not go out of the State. Where the work is largely of purely local interest, as in the drainage surveys, a large part of the expense is borne by the local interests.

RELATIONS TO THE PUBLIC.

In common with all of the national and State Surveys, the Geological Survey of Tennessee has certain rules and regulations which prohibit the director or any member of the Survey from having any personal or private interest in any of the lands or mineral wealth of a region under survey or from executing any surveys or examinations for private parties or corporations in this State. This is absolutely necessary if the reports of the Survey are to be kept free from any suspicion of bias or willful misrepresentation.

Except where the results will be of large public interest, the Survey will not undertake the examination of property for private parties, as that work properly belongs to the mining geologist or mining engineer.

Rocks or minerals properly packed and sent, postpaid, to the director will be examined without cost, providing an assay or chemical analysis is not necessary. Exception to the latter rule may be made if the director believes the specimen to contain valuable mineral, the determination of which will be of value to the work of the Survey and an aid in the study of the resources of the State. When requested, names of reliable parties will be given, who may be employed to furnish assays or chemical analyses. The Survey reserves the right to publish, at any time, any assay or analysis made at its expense.

Two of the regulations are of such character that they had best be quoted in full:

"Members of the survey are expressly forbidden to give individuals or corporations, in advance of publication, the results arrived at in the course of geological examination in a district or area. They are at liberty, however, to communicate orally to the owner or manager of a mineral property, during the progress of its investigation, such information with regard to the geology of that property as may be of value to him in its development; but written statements must be avoided, lest they be used for promoting or unduly enhancing values."

"Information of a confidential character, such as mine maps, drill records, statistics of production, etc., supplied by private parties or corporations, must be carefully guarded and used in the preparation of reports for publication strictly in accordance with the conditions stipulated by the persons furnishing it."

In general, in planning the work for each season, the plans are largely influenced by the volume and character of inquiries for information that have been received, modified by the existence of adequate base maps or other limiting factors. As already explained, it will not pay to attempt to do detailed geological work in a region

where no adequate base map exists, and before work of that character can be done in such a region, such an adequate base map must be prepared. It will, however, often be possible to make reconnoissance surveys in regions which have not as yet been topographically mapped. At the present time, with the small number of up-to-date base maps available, that factor, more than any other, will determine where the detailed work is to be done. In the beginning, however, a large amount of reconnoissance work will be desirable in order to prepare preliminary general bulletins.

It may often happen that residents of a district believe that district to contain deposits of economic value, and under these circumstances the director would be very glad to have his attention called to the matter, and, subject to the limitations imposed by the facilities of the Survey, would gladly comply with requests for such examination, provided a sufficient number of people are interested in the matter to justify the expenditure of the State appropriation and provided that such requests are made early enough in the year so that advance plans may be made for the doing of such work at the time that plans are made for the season's work.

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